

FIG.1

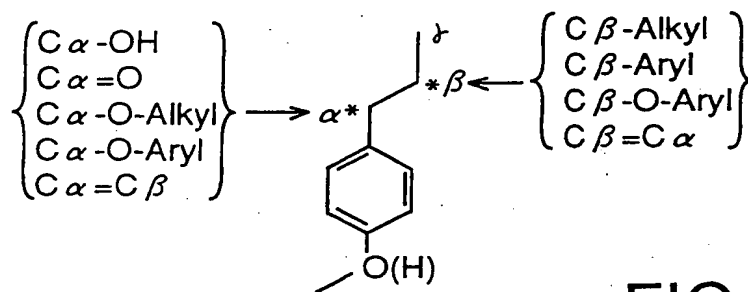


FIG.2

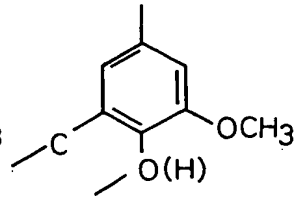
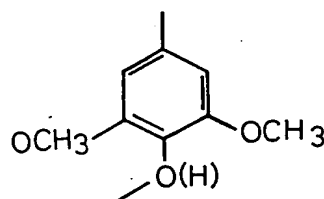
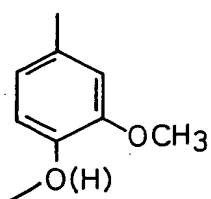
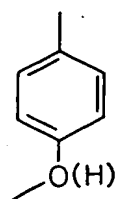


FIG.3 (a) FIG.3 (b) FIG.3 (c) FIG.3 (d)

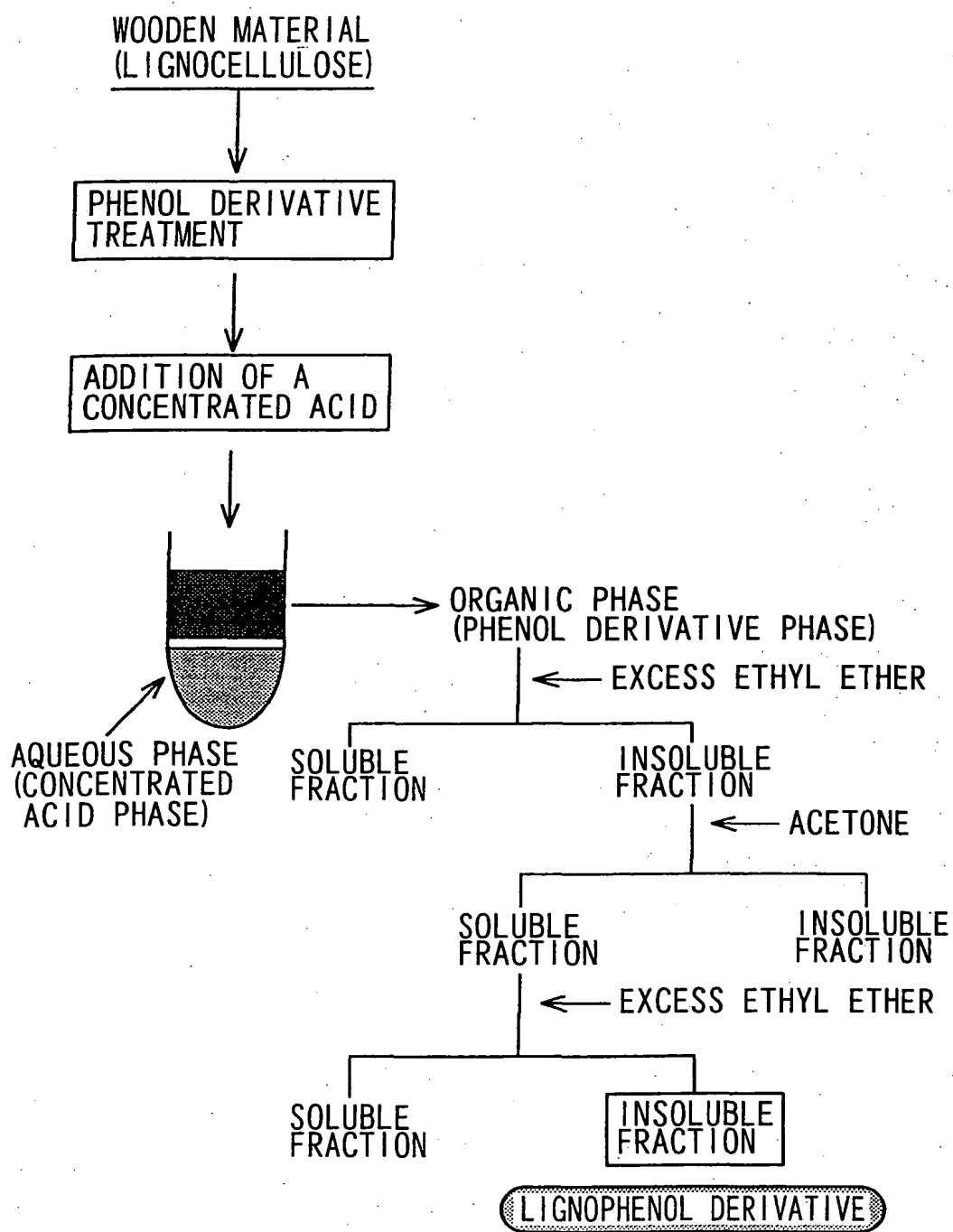


FIG.4

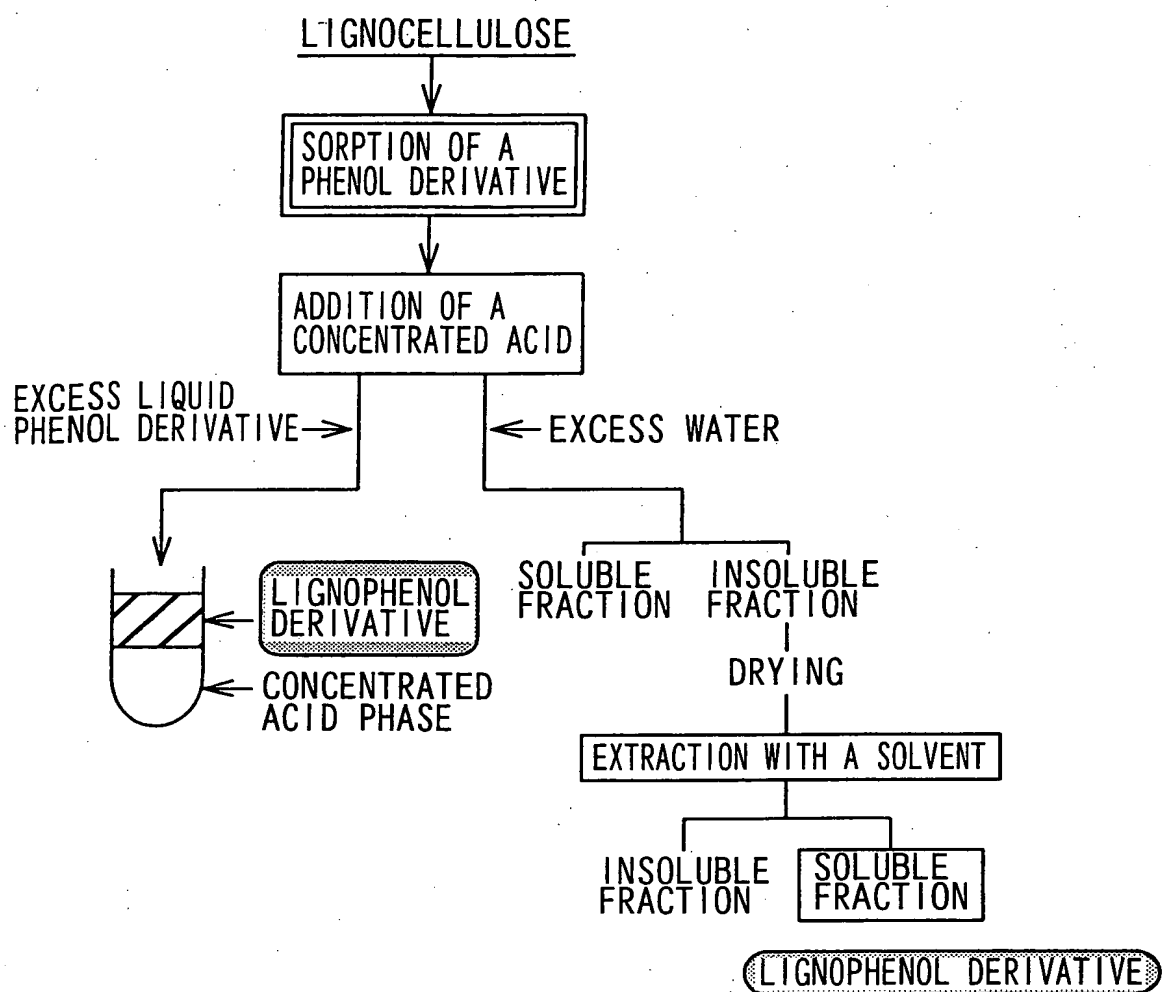


FIG.5

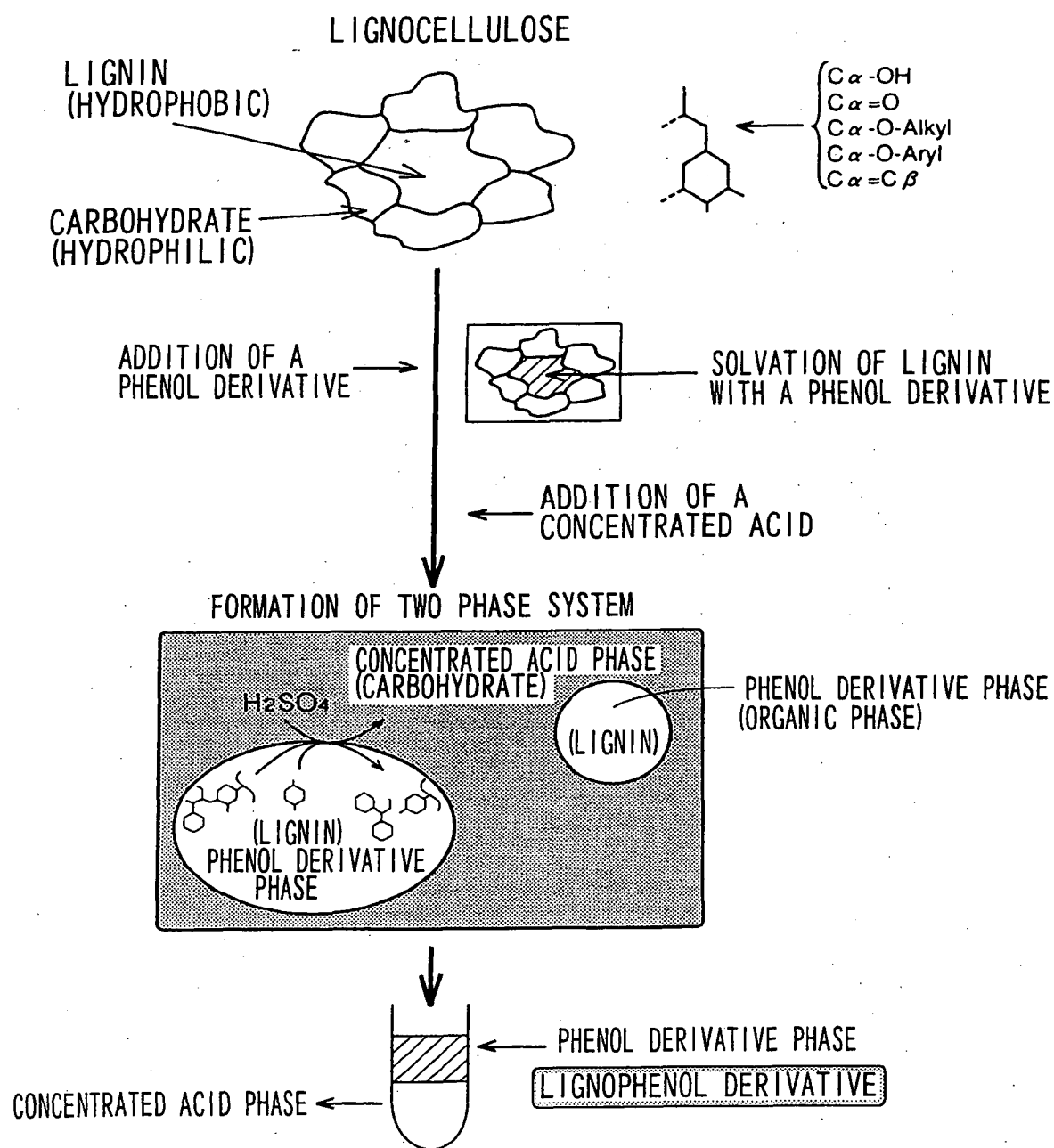


FIG.6

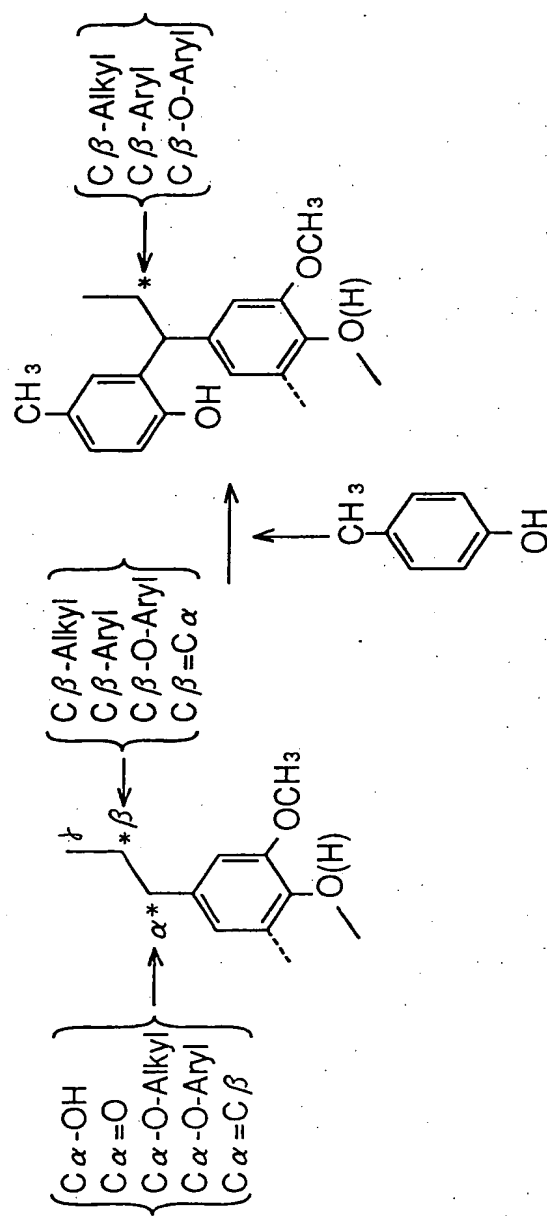


FIG.7

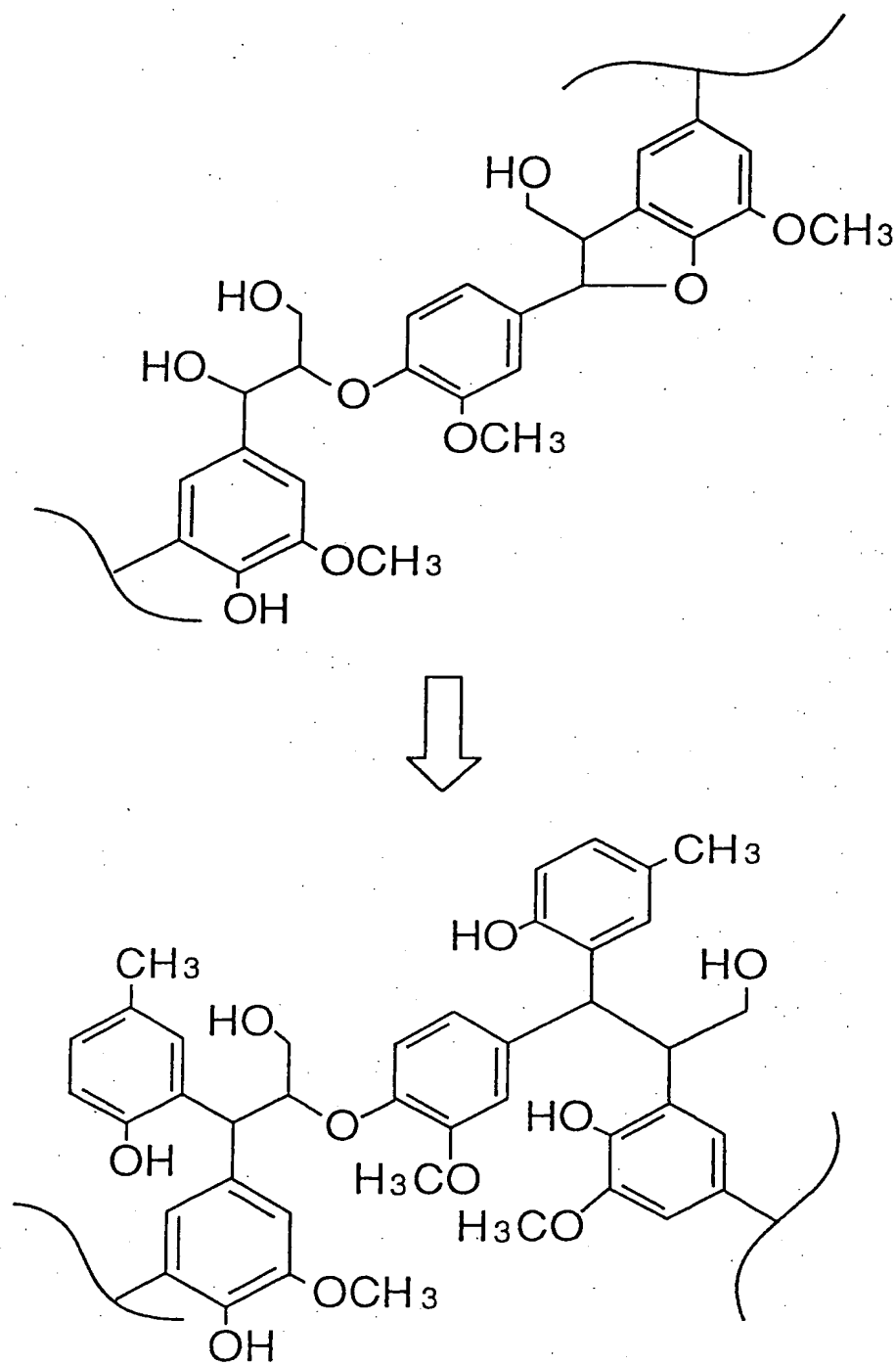


FIG.8

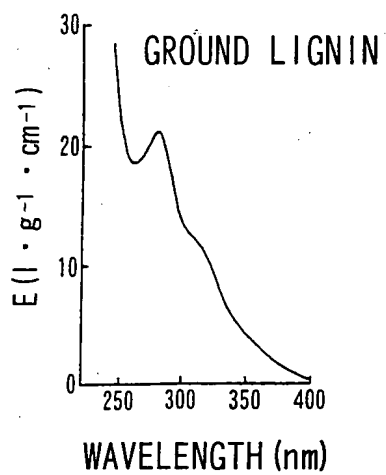


FIG.9 (a)

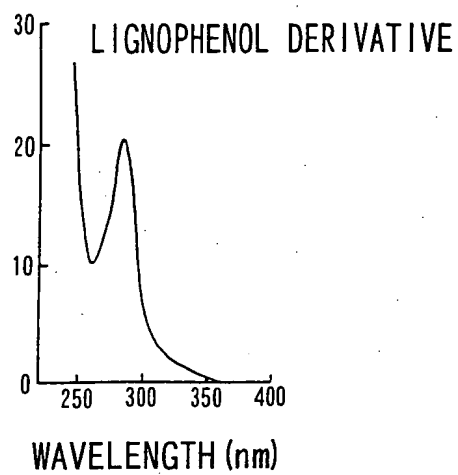


FIG.9 (b)

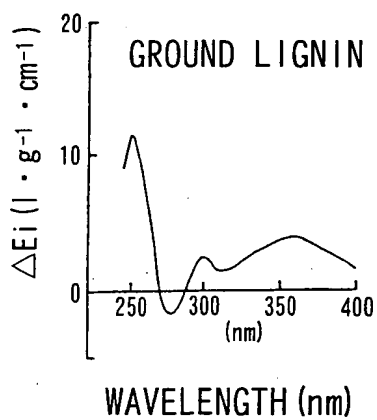


FIG.10 (a)

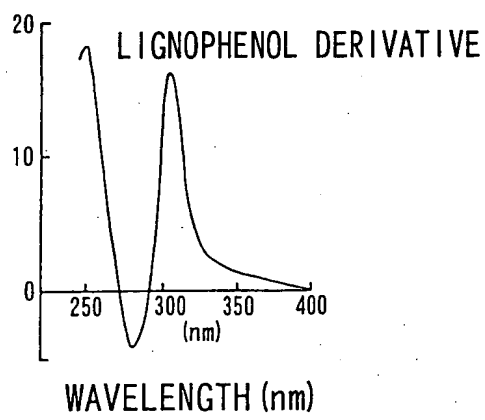


FIG.10 (b)



FIG.11 (a)

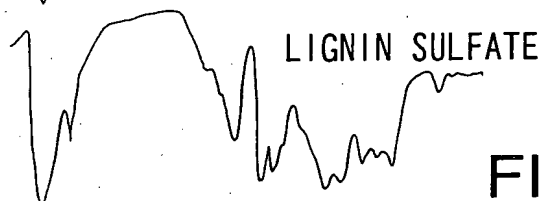


FIG.11 (b)

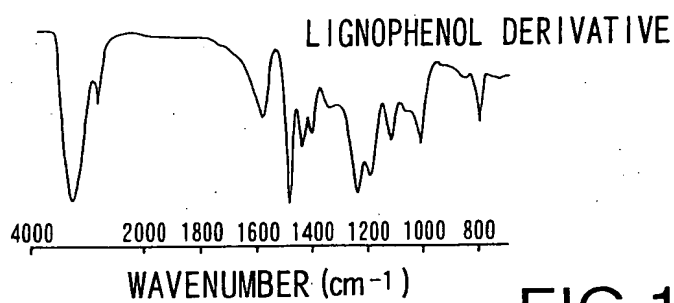


FIG.11(c)

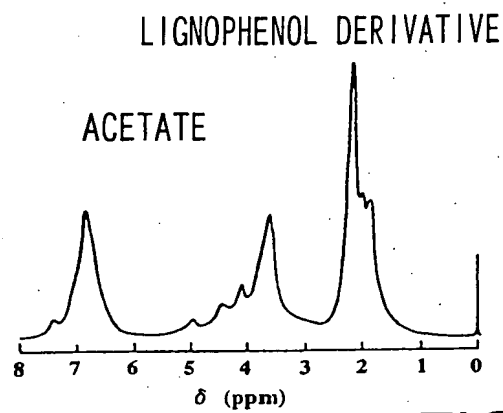


FIG.12 (a)

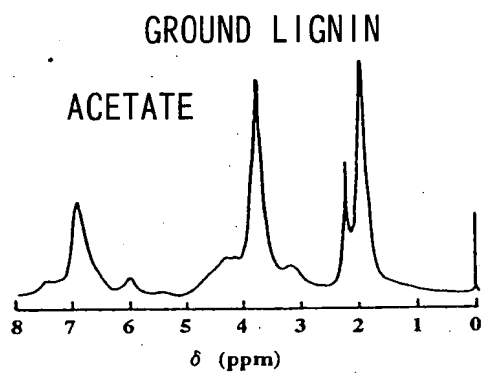


FIG.12 (b)

SAMPLE		YIELD (% of Klason lignin)
Yezo spruce	(<i>Picea jezoensis</i>)	108.2
Japanese fir	(<i>Abies firma</i>)	111.8
Japanese cedar	(<i>Cryptomeria japonica</i>)	110.3
Japanese birch	(<i>Betula platyphylla</i>)	103.0
Japanese oak	(<i>Quercus mongolica</i>)	109.3
Apitong	(<i>Dipterocarpus grandiflorus</i>)	101.6

FIG.13

SAMPLE	ELEMENTARY ANALYSIS RESULTS			INTRODUCED CRESOL		APPEARANCE	DISSOLVING SOLVENT
	C	H	O	%	mol/C ₉		
GROUND LIGNIN							
Yezo spruce (<i>Picea jezoensis</i>)	61.5	5.8	32.7				
LIGNOPHENOL DERIVATIVE							
Yezo spruce (<i>Picea jezoensis</i>)	66.8	6.0	27.2	25.9	0.65	Light pink	Methanol Ethanol Acetone Dioxane THF Pyridine DMF etc.
Japanese fir (<i>Abies firma</i>)	66.5	5.8	27.7	25.0	0.62		
Japanese cedar (<i>Cryptomeria japonica</i>)	66.2	5.9	27.9	24.8	0.62		
Japanese birch (<i>Betula platyphylla</i>)	59.7	6.1	34.2				
Japanese birch (<i>Betula platyphylla</i>)	64.3	6.0	29.7	30.9	0.90	Light pink	
Japanese oak (<i>Quercus mongolica</i>)	65.0	6.1	28.9	26.0	0.81		
Apitong (<i>Dipterocarpus grandiflorus</i>)	67.9	6.1	26.0	33.2	0.92		

FIG.14

SAMPLE	HYDROXYL GROUP (mol/C9)		
	C α	C γ	Phenolic
GROUND LIGNIN			
Yezo spruce (<i>Picea jezoensis</i>)	0.35	0.80	0.35
LIGNOPHENOL DERIVATIVE			
Yezo spruce (<i>Picea jezoensis</i>)	Trace	0.79	1.26
Japanese fir (<i>Abies firma</i>)	Trace	0.89	1.32
Japanese cedar (<i>Cryptomeria japonica</i>)	Trace	0.86	1.31
GROUND LIGNIN			
Japanese birch (<i>Betula platyphylla</i>)	0.53	0.82	0.32
LIGNOPHENOL DERIVATIVE			
Japanese birch (<i>Betula platyphylla</i>)	Trace	0.80	1.51
Japanese oak (<i>Quercus mongolica</i>)	Trace	0.88	1.51
Apitong (<i>Dipterocarpus grandiflorus</i>)	Trace	0.91	1.58

FIG.15

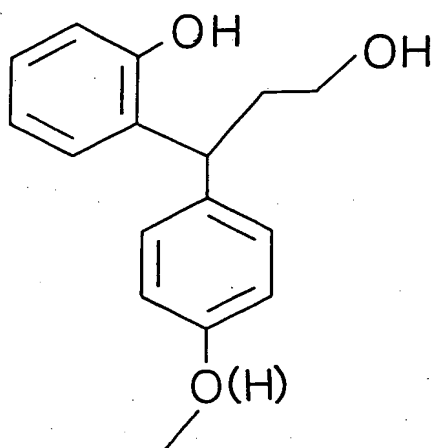


FIG.16

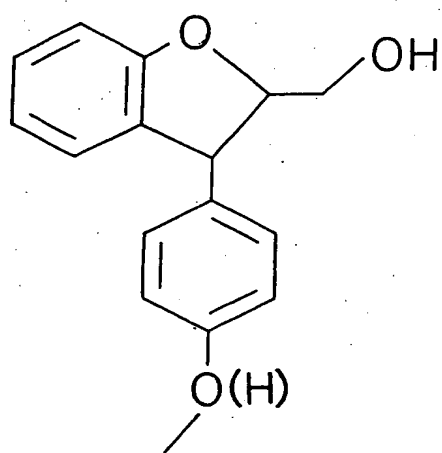


FIG.17

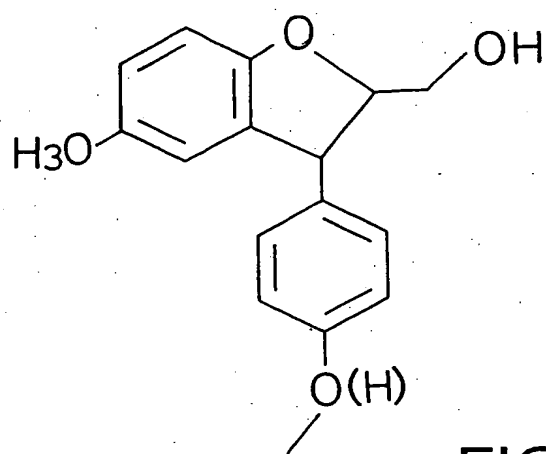


FIG.18

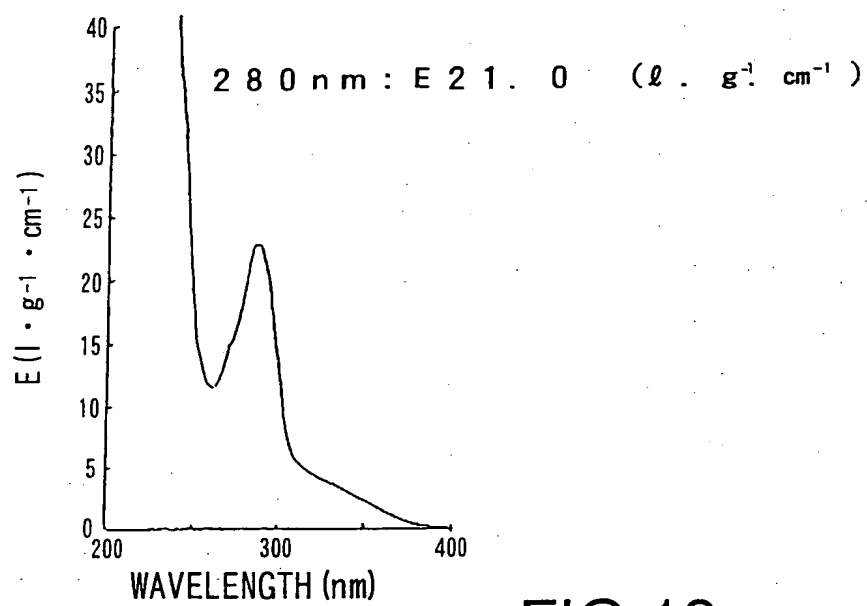


FIG.19

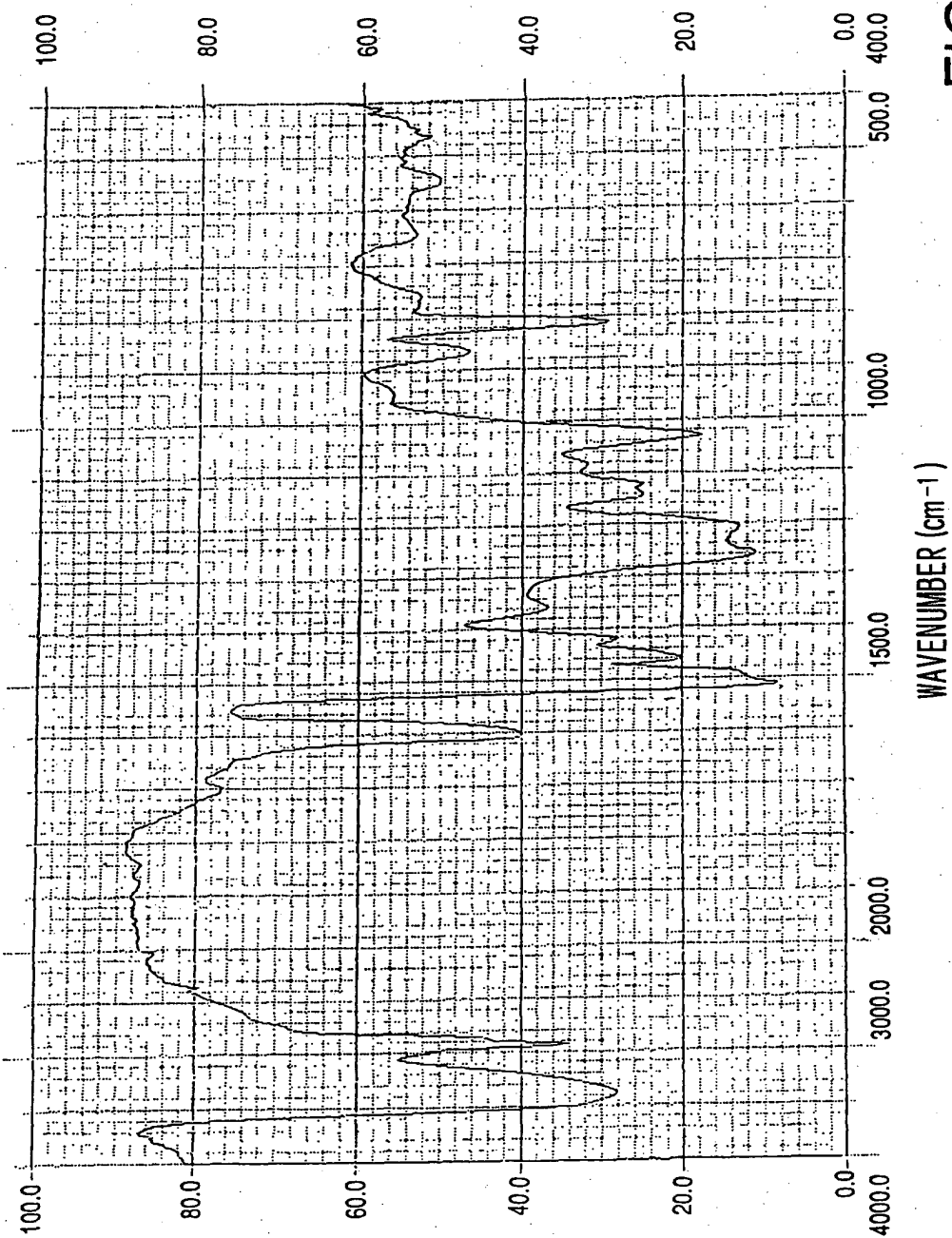


FIG.20

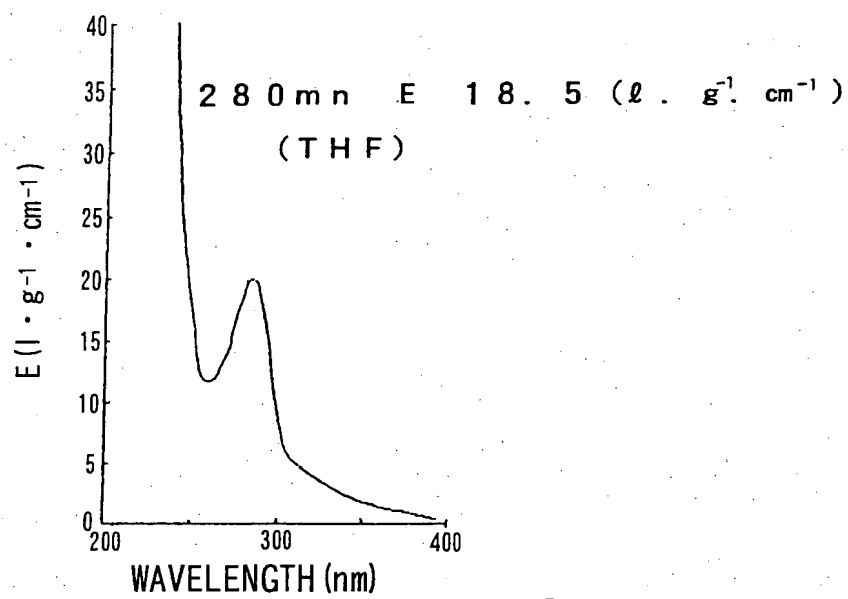


FIG.21

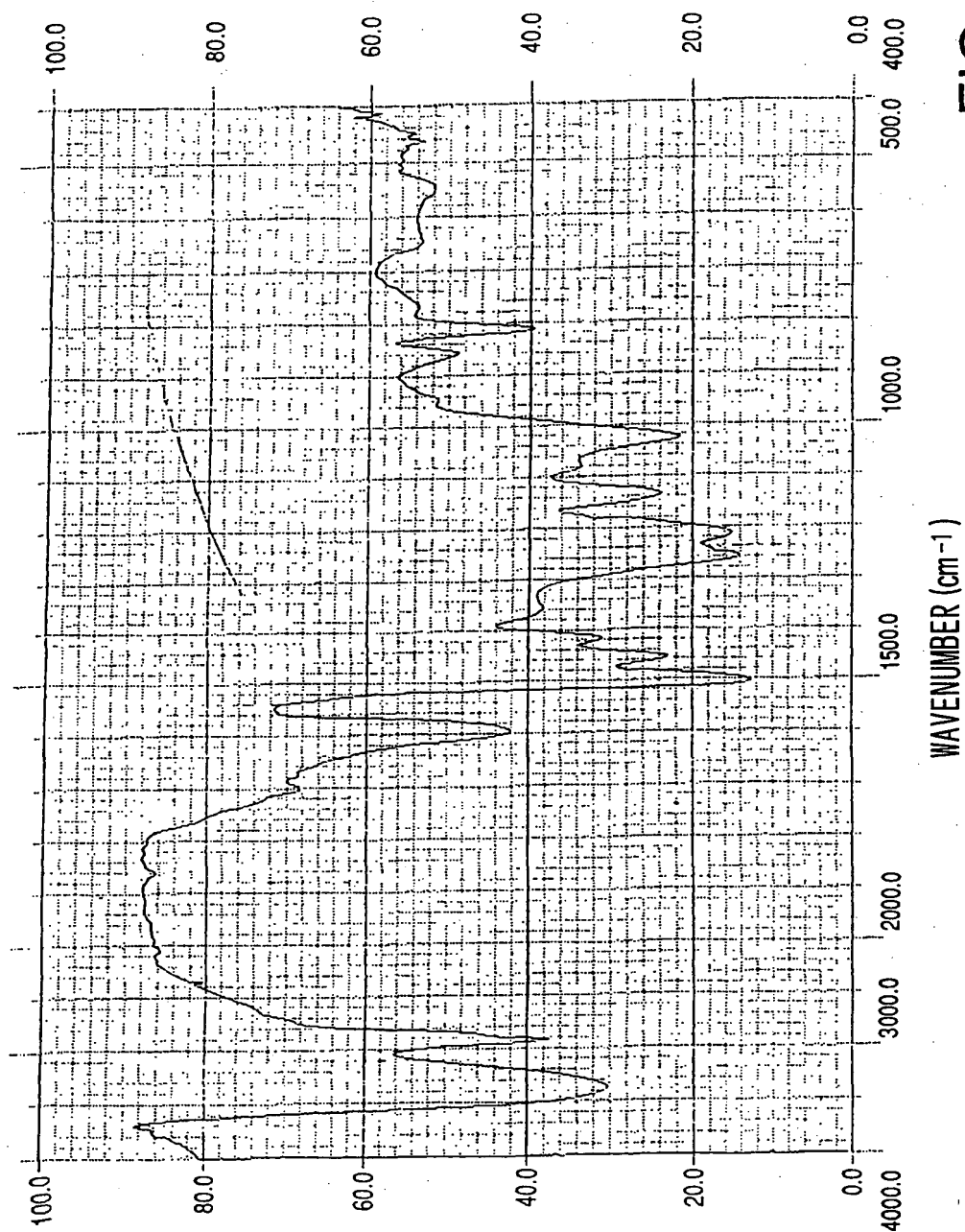
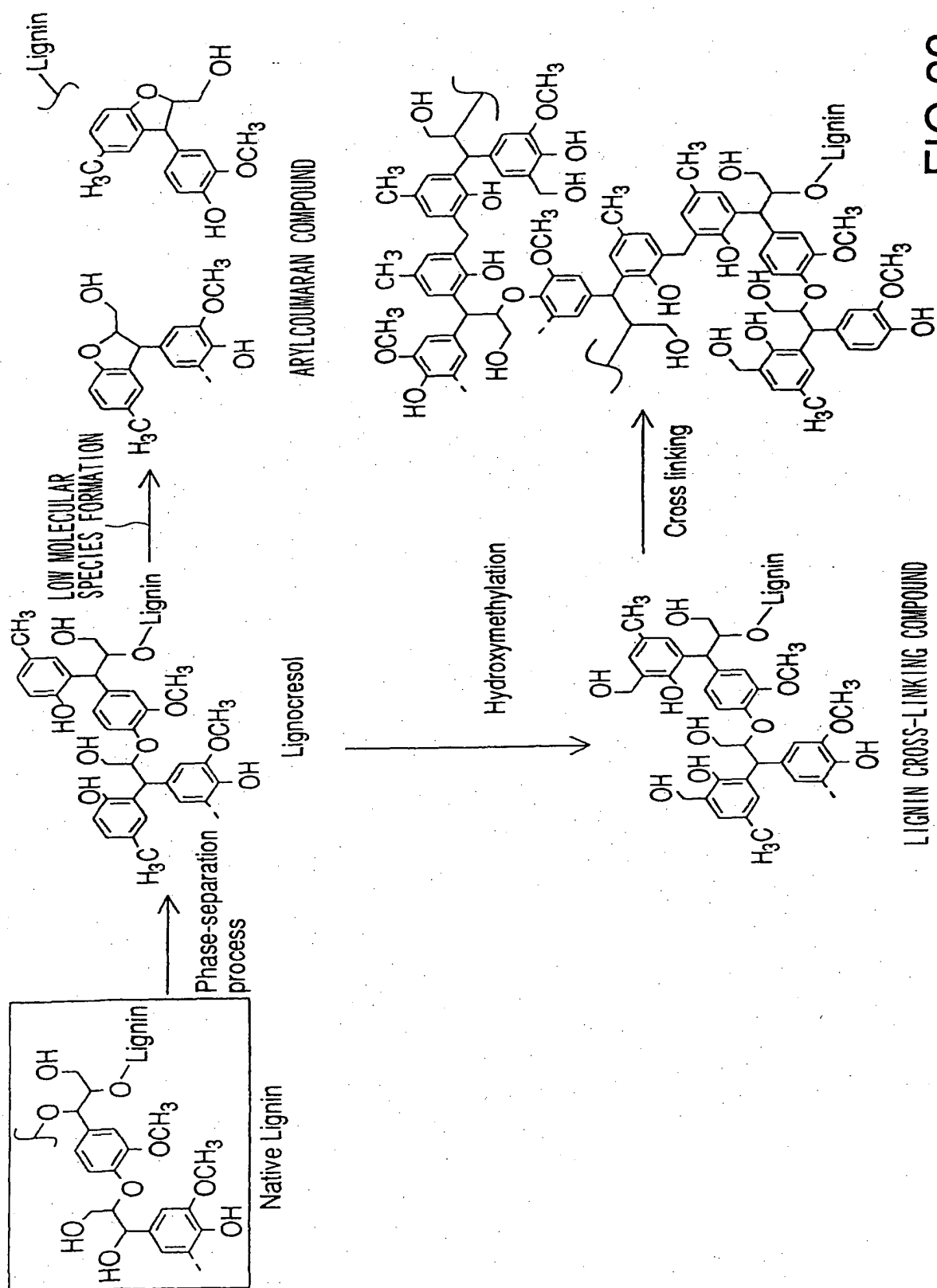


FIG.22



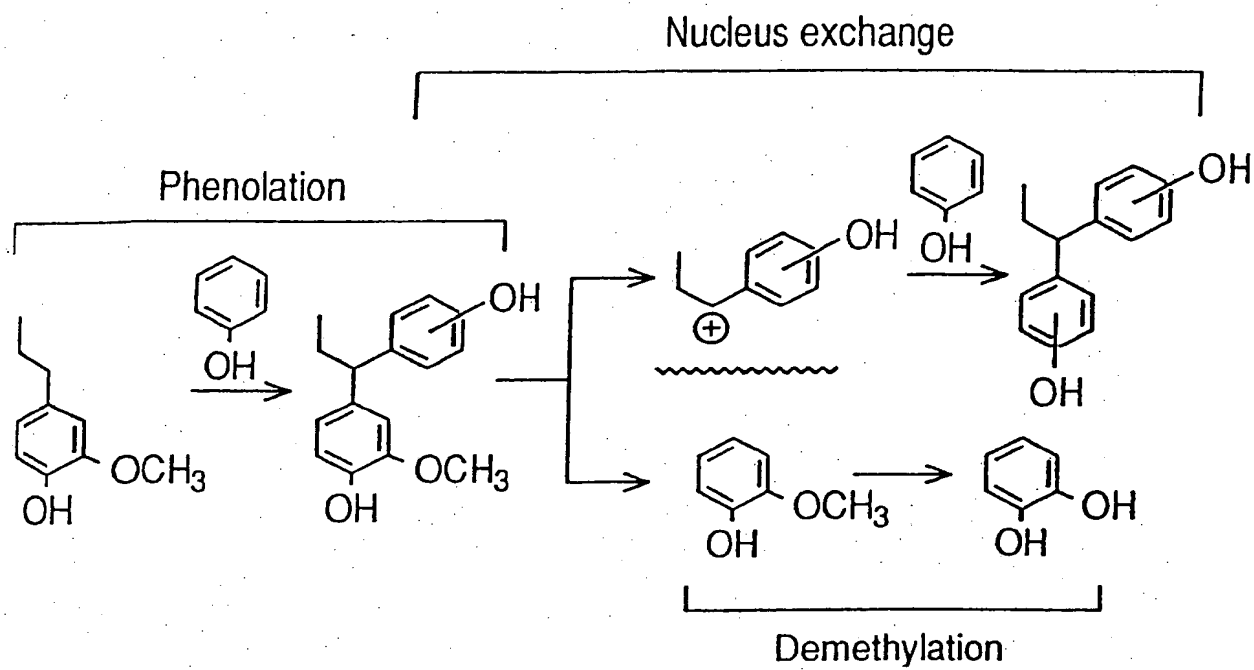


FIG.24

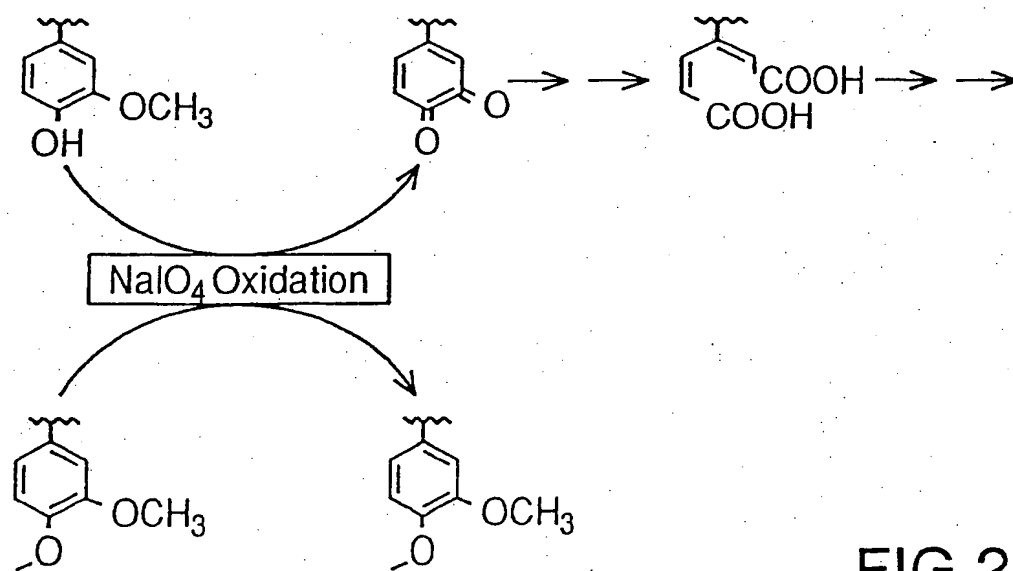


FIG.25

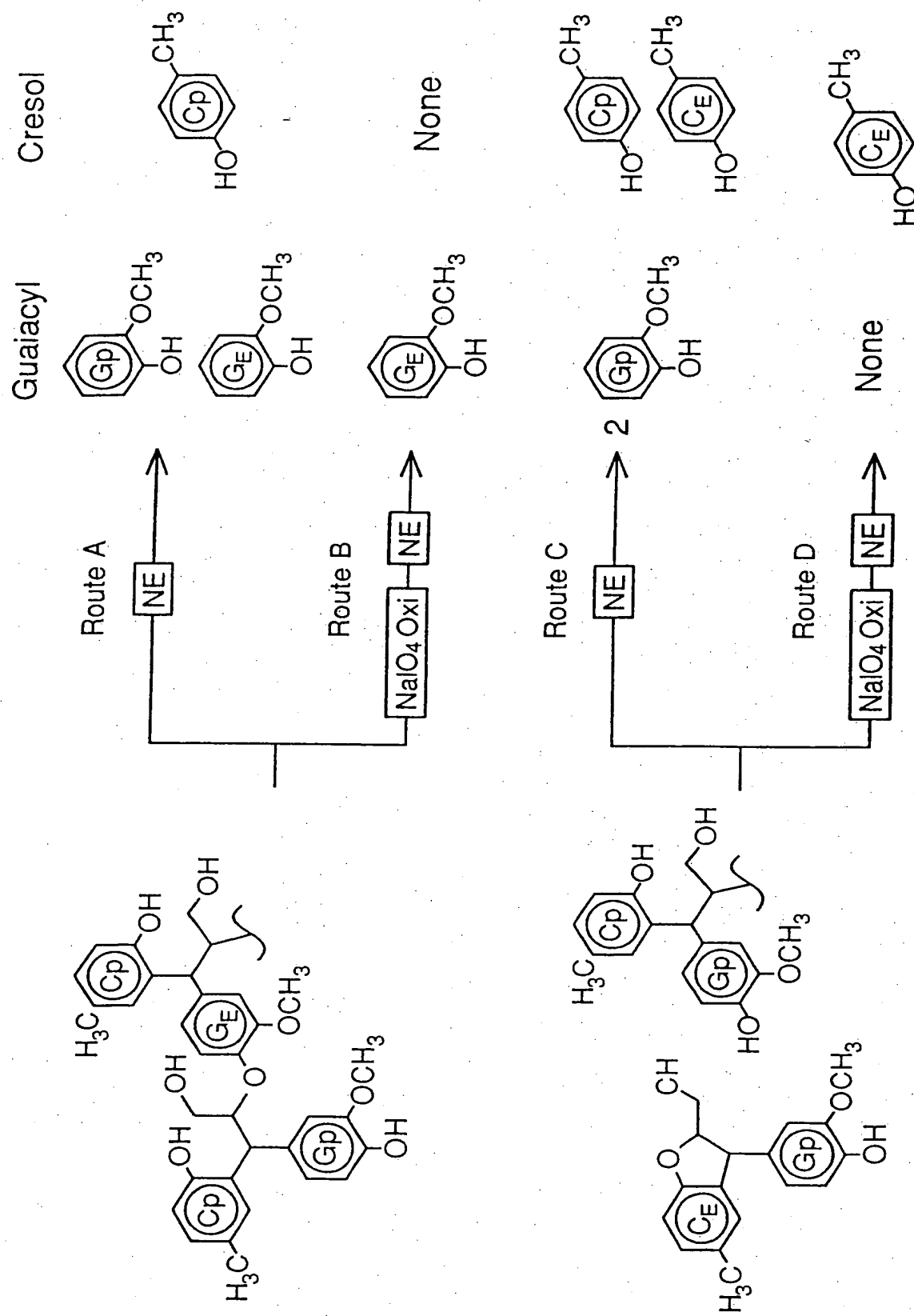


FIG.26

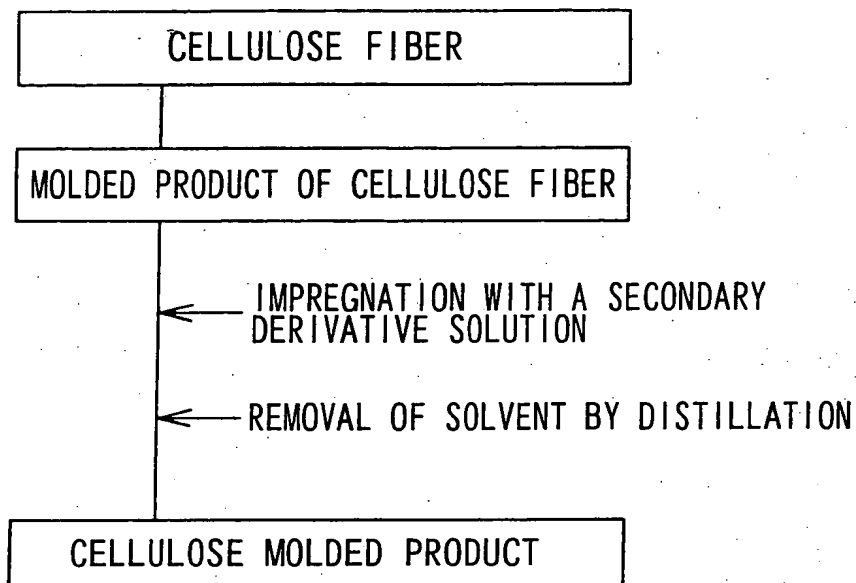


FIG.27

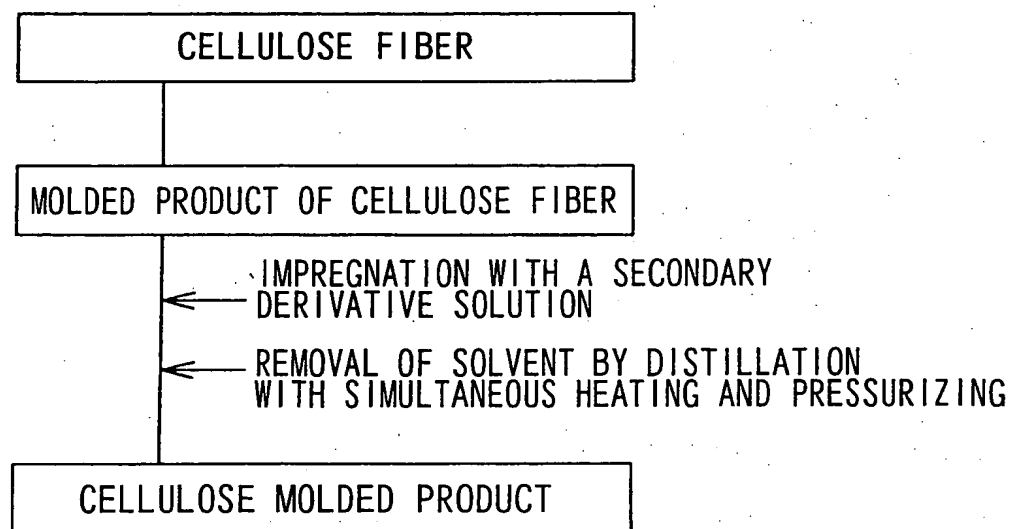
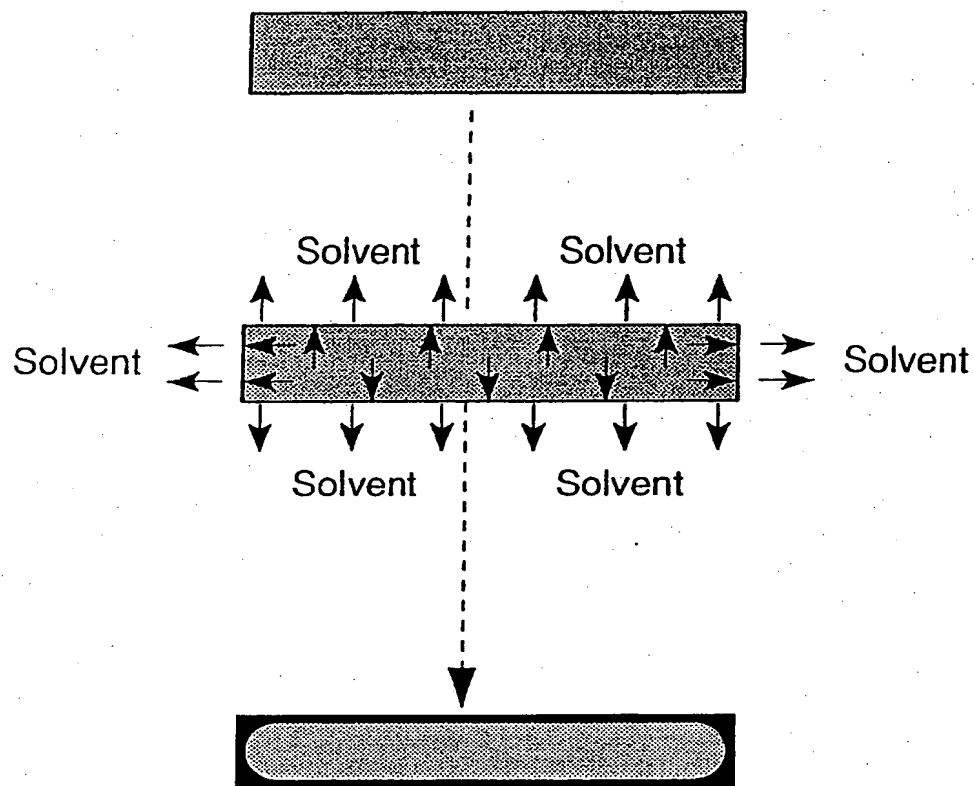


FIG.28

Mold Sorption Method



Gradient sorption

FIG.29

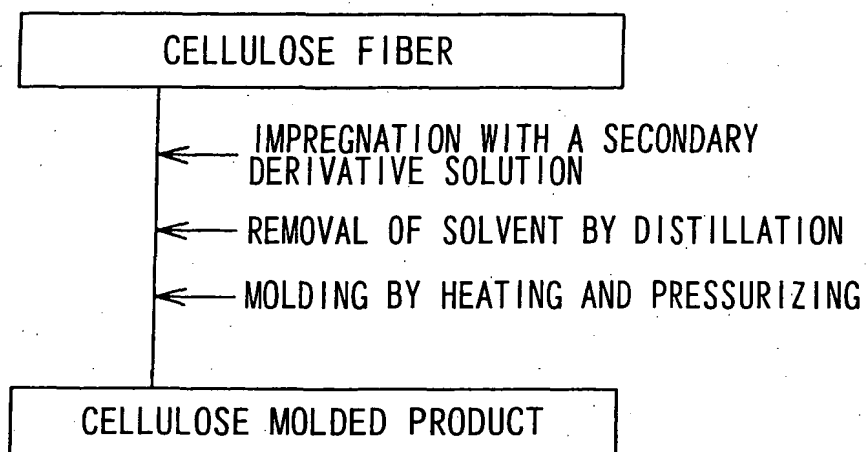


FIG.30

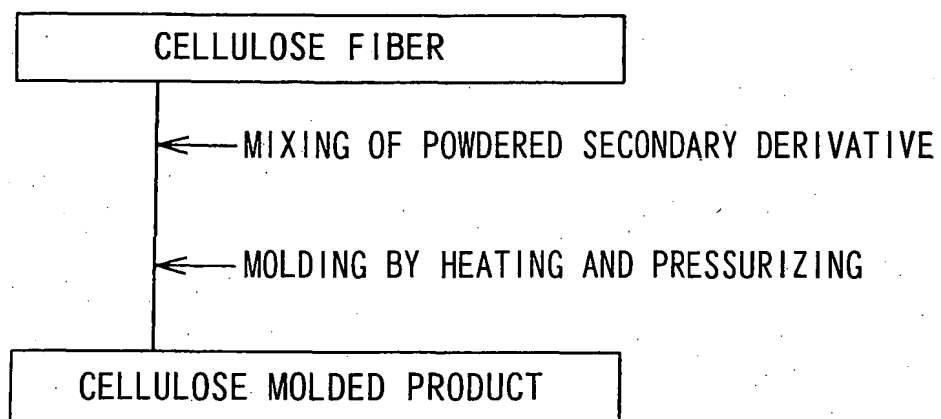


FIG.31

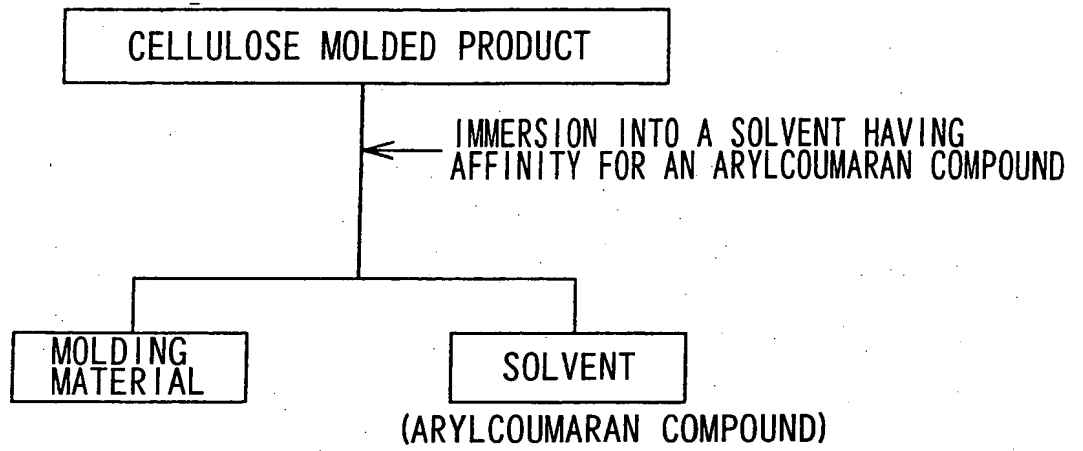


FIG.32

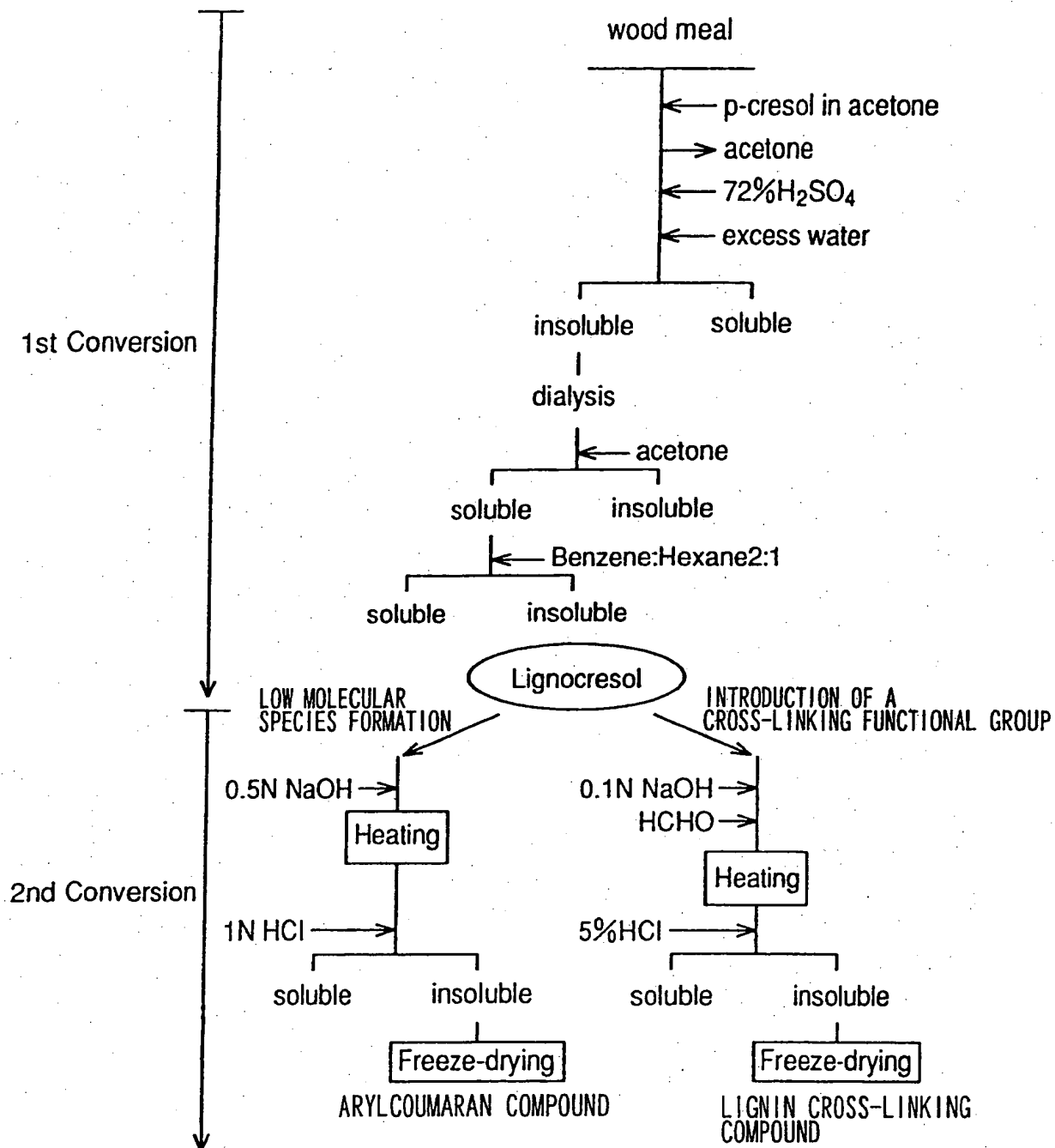


FIG.33

SAMPLE	YIELD (%)	AVERAGE MOLECULAR WEIGHT			AMOUNT OF INTRODUCED CRESOL	
		\overline{M}_w	\overline{M}_n	$\overline{M}_w / \overline{M}_n$	Wt%	mol/C ₉
LIGNOCRESOL	—	8355	2737	3.053	26.70	0.68
ARYLCOUMARAN COMPOUND	81.07	1261	576	2.190	24.41	0.60

FIG.34

SAMPLE	HYDROXYL GROUP (mol/C ₉)		FREQUENCY OF PHENOLIC RINGS		
	Phenolic Wt% mol/C ₉	Aliphatic Wt% mol/C ₉	Guaiacyl (% of total guaiacyl) (% of total cresol)		Cresol (% of total cresol)
LIGNOCRESOL	9.94	1.60	6.21	1.00	46.04
ARYLCOUMARAN COMPOUND	9.75	1.51	7.68	1.19	81.14
					67.83

FIG.35

SAMPLE	YIELD (%)	AVERAGE MOLECULAR WEIGHT			AMOUNT OF INTRODUCED CRESOL	
		\overline{M}_w	\overline{M}_n	$\overline{M}_w / \overline{M}_n$	Wt%	mol/C9
LIGNOCRESOL	—	10691	3260	3.279	13.62	0.30
LIGNIN CROSS-LINKING COMPOUND	91.58	2894	919	3.149	13.76	0.30

FIG.36

SAMPLE	HYDROXYL GROUP (mol/C9)				HYDROXYMETHYL GROUP (mol/C9)	
	Phenolic		Aliphatic			
	Wt%	mol/C9	Wt%	mol/C9	Wt%	mol/C9
LIGNIN CROSS-LINKING COMPOUND	7.75	1.06	10.55	1.44	6.90	0.56

FIG.37

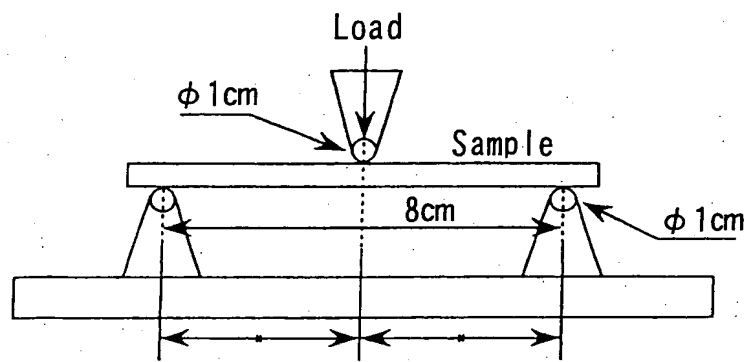


FIG.38

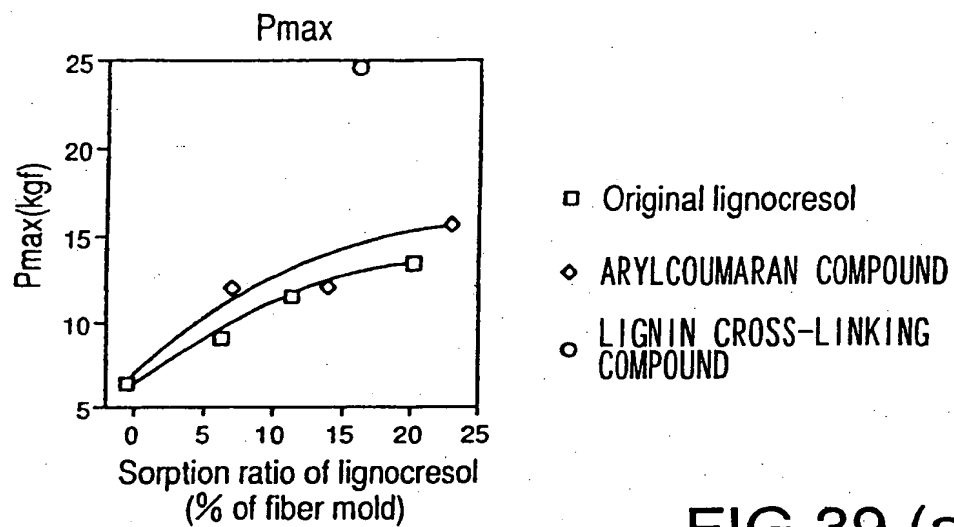


FIG.39 (a)

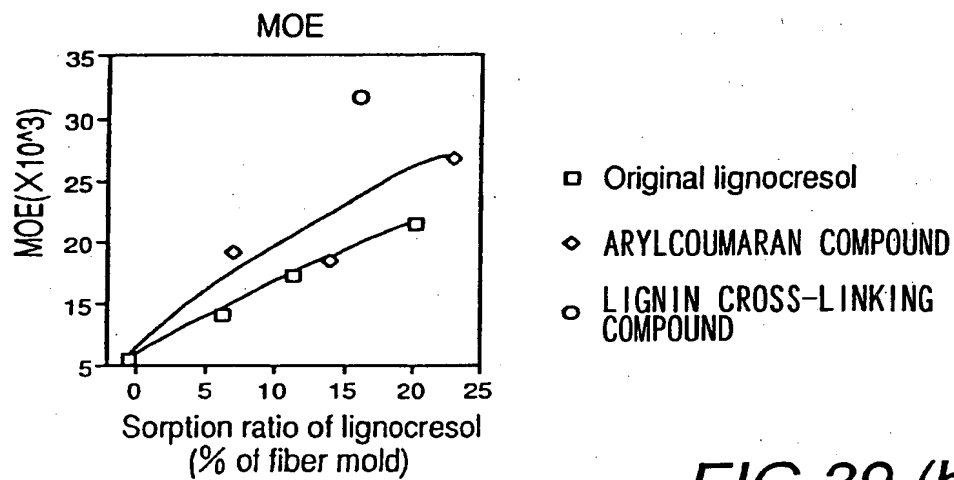


FIG.39 (b)

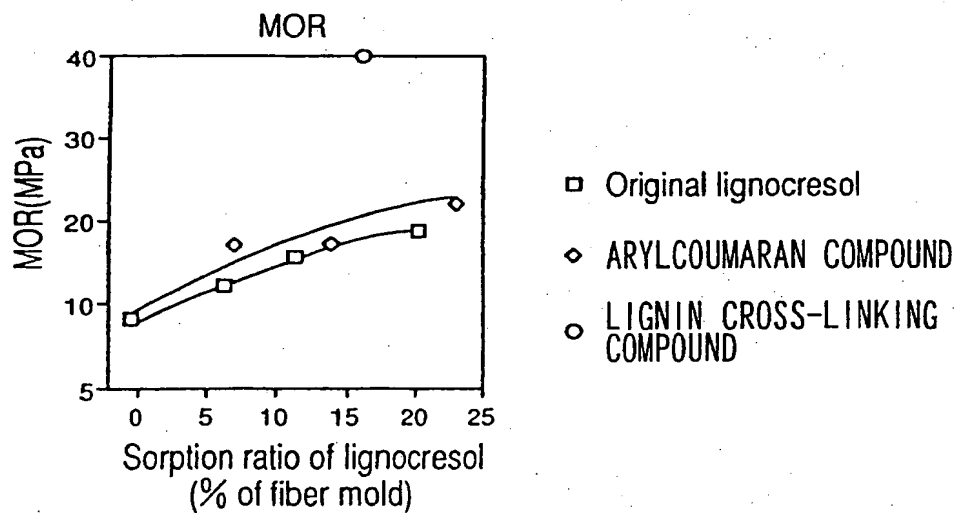
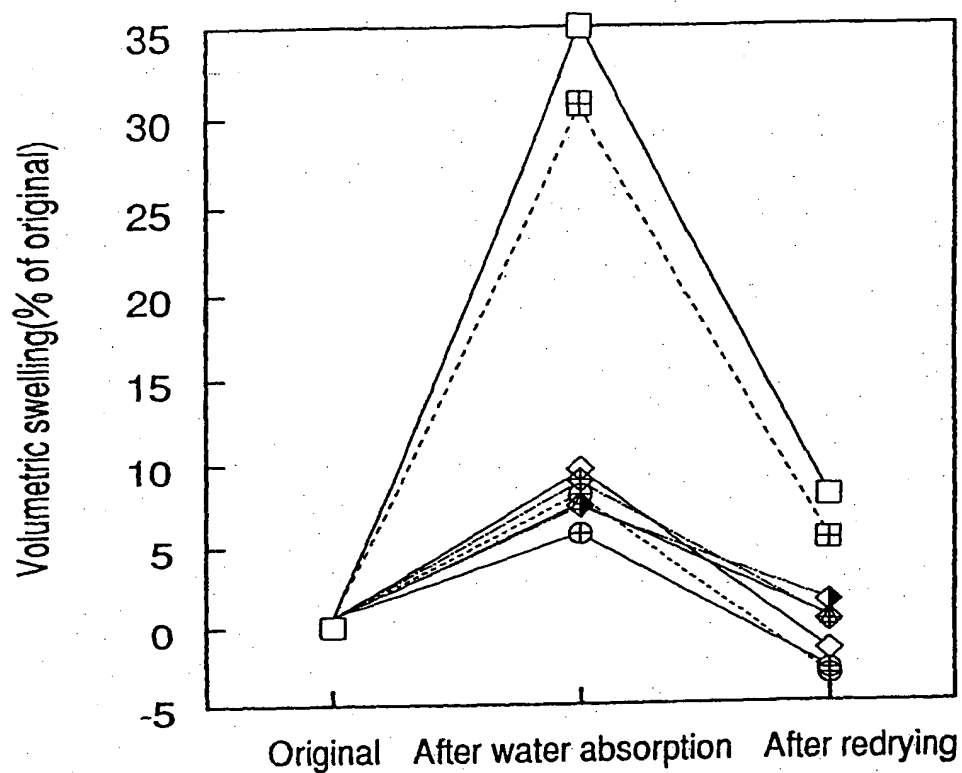


FIG.39 (c)



Unheated

Heated

—□—

Control

---□---

—◇—

5%

—◇—

---⊕---

10%

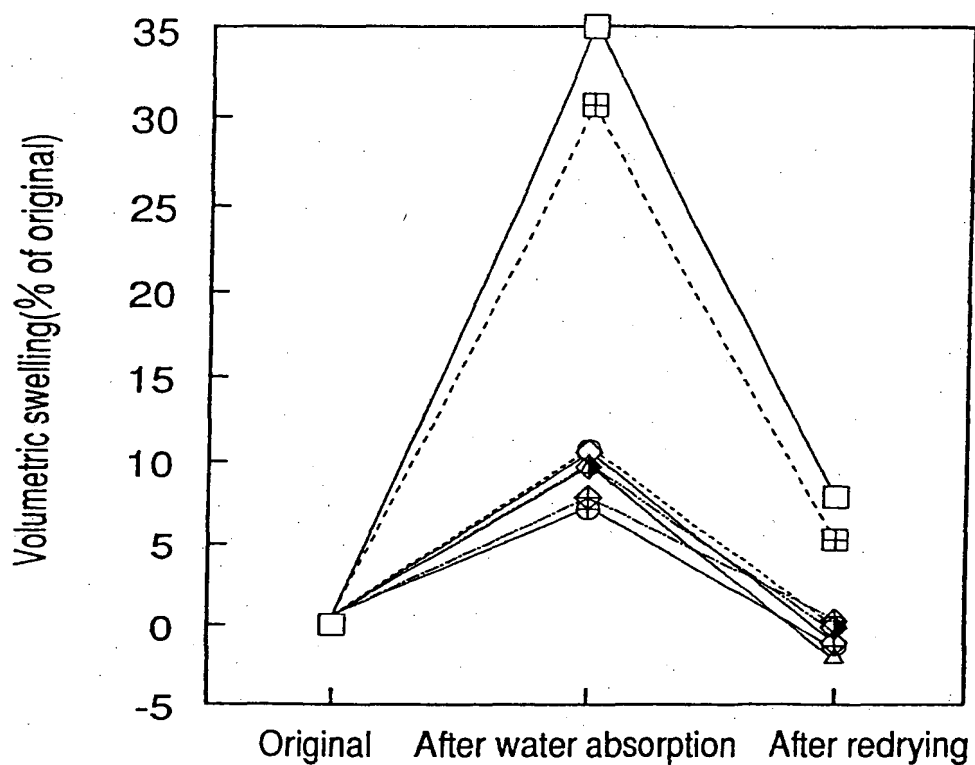
---⊕---

—△—

20%

—◆—

FIG.40



Unheated

Heated

—□—

Control

---□---

—◇—

5%

---◇---

---○---

10%

—⊕—

—△—

20%

---◆---

FIG.41

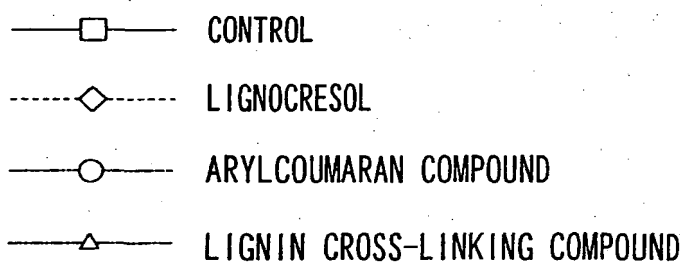
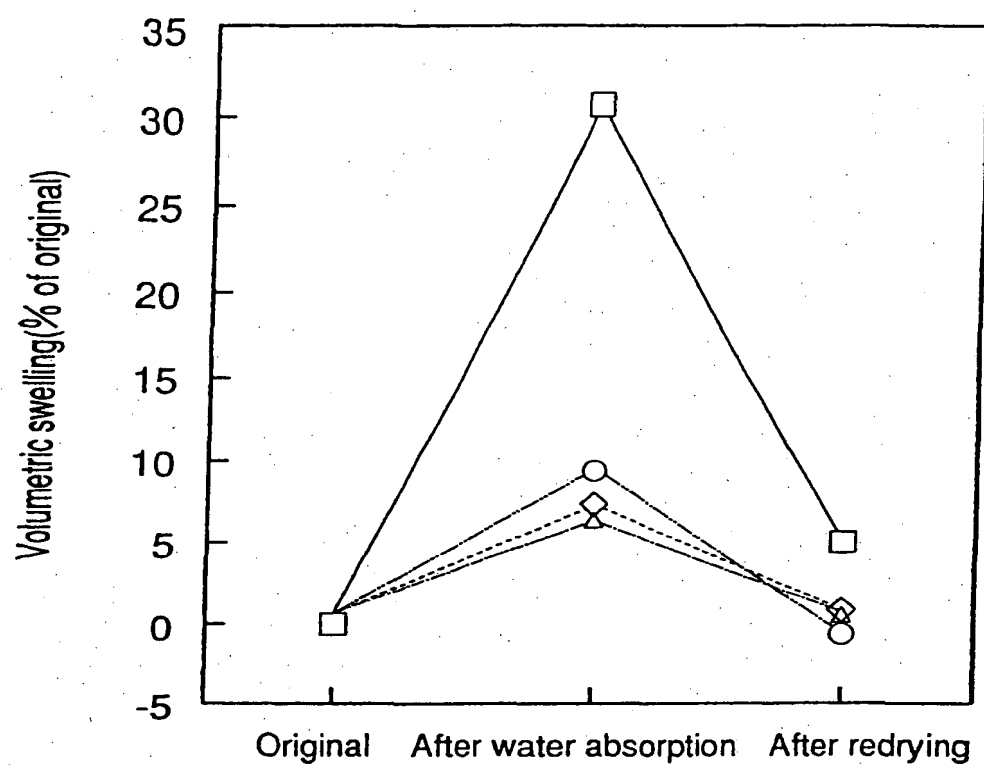


FIG.42

SAMPLE	SPECIFIC GRAVITY	WATER ABSORPTION * 1	VOLUMETRIC INCREASE * 2	
			AFTER WATER ABSORPTION	AFTER DRYING
CONTROL	0.475	167.88	30.52	5.22
LIGNOCRESOL	0.557	15.69	7.43	1.01
ARYLCOUMARAN COMPOUND	0.559	15.64	9.36	-0.51
LIGNIN CROSS-LINKING COMPOUND	0.596	9.34	6.55	0.77

* 1 : % RELATIVE TO WEIGHT BEFORE WATER ABSORPTION

* 2 : % RELATIVE TO VOLUME BEFORE WATER ABSORPTION

FIG.43

RECOVERY RATE OF A LIGNIN DERIVATIVE FROM A MOLDED PRODUCT
(% RELATIVE TO WEIGHT OF AN ATTACHED LIGNIN DERIVATIVE)

SAMPLE	UNHEATED	HEATED
LIGNOCRESOL	99.28	94.10
ARYLCOUMARAN COMPOUND	100.00	100.00
LIGNIN CROSS-LINKING COMPOUND	—	Trace

FIG.44